

# Provocation Lumbar Diskography at Previously Fused Levels

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## Summary

Recurrent or persistent low back pain (LBP) after lumbar fusion can be related to many factors. We reviewed the provocation lumbar diskogram (PLD) features and redo-fusion outcome in our patients evaluated for recurrent/persistent LBP after technically successful fusion. LD was performed in 27 patients with recurrent/persistent LBP after prior successful lumbar surgical fusion (31 fused levels: single-level fusion-23; two-level fusion-4). PLD response and imaging characteristics at fused and non-fused levels were assessed including: intra-diskal lidocaine response, diskogram-image/post-diskogram CT appearance, presence/absence of diskographic contrast leakage, and evidence of fusion integrity or hardware failure. Outcomes in patients having redo-fusion were assessed.

Concordant pain was encountered at 15 out of 23 (65%) single-level fusions, non-concordant pain in one fusion with non-painful response in seven. Adjacent-level concordant pain was identified in seven out of 23 (30%) patients (three of 15 with painful fused levels; four of seven with non-painful fusions). In two-level fusions, concordant pain was encountered at one fused level in each patient. In painful fused levels, leaking and contained disks were encountered with partial or complete pain elimination after intra-diskal lidocaine injection. In anterior fusions, space or contrast surrounding the cage was noted at five of 11 levels. Pseudoarthrosis was noted only with trans-sacral screw fusions. Redo-fusion in 13 patients resulted in significant improvement in nine and moderate improvement in one.

*Patients with recurrent/persistent LBP after technically successful fusion may have a diskogenic pain source at the surgically fused or adjacent level confirmed by lidocaine-assisted PLD.*

## Introduction

Identifying the cause of recurrent or persistent low back pain (LBP) after uncomplicated lumbar surgical fusion can be challenging. Altered spine mobility may contribute to accelerated degenerative change or increased stress at adjacent levels affecting the disk, facets and/or sacroiliac joints leading to pain<sup>1-6</sup>. Pseudoarthrosis and renewed instability related to hardware loosening/breakage and inter-body cage migration at the fused level(s) are also important considerations<sup>7-10</sup>.

Provocation lumbar diskography is primarily used to confirm a diskogenic source of LBP when no clear cause is present based on physical exam and imaging<sup>11</sup> or for pre-operative planning prior to fusion to assess for single or multi-level diskogenic pain<sup>8,12-15</sup>. To our knowledge, only two published studies exist where diskography has also been used to assess for a potential pain source in patients who have undergone surgical fusion but have persistent or recurrent axial LBP<sup>16,17</sup>. These reports have demonstrated that concordant pain may be present at successfully fused levels even prompting the need for surgical revision. While the incidence is not known and mechanism not fully understood, persistent/recurrent pain at technically successful fused levels (correct and secure construct placement at time of surgery) would

undoubtedly affect fusion outcome results. The purpose of this study was to present the observed clinical and imaging features of patients with prior fusion but persistent/recurrent LBP who underwent provocation lumbar diskography at the previously fused disk levels.

### Materials and Methods

Between June 2004 and April 2008, provocation lumbar diskography (PLD) was performed in 390 consecutive patients at our institution by one of two experienced interventional spine neuroradiologists. In 38 patients, prior lumbar fusion was present, and in 27 of these 38 patients diskography was performed at the previously fused level due to unresolved or recurrent LBP consistent with or similar to the original LBP symptoms. These 27 patients comprised the patient cohort for this study. All fusions were technically successful at surgical placement of the construct. The clinical and provocation diskogram features in these 27 patients were retrospectively assessed. Institution review board approval was obtained for this retrospective study. At diskography it was chosen not to study the previously fused level in 11 patients since their pre-fusion pain resolved after fusion and their current presenting LBP symptoms was new and differed from the original pain.

#### *Lumbar Diskography Technique*

Diskography was performed in a standard fashion as previously described<sup>18,19</sup>. Back pain versus leg pain contribution was clarified. The patient's most severe and immediate pre-procedure pain level was documented employing the 0-10 Visual Analog Scale (VAS). Limited intravenous sedation (fentanyl 0.05 mg, Versed 1 mg [midazolam, Bedford Laboratories; Bedford, OH, USA]) was given before the procedure, occasionally supplemented during the study with fentanyl given at the end of the examination. Administration of additional fentanyl was necessary only on rare occasions when disc provocation resulted in extremely severe pain not responsive to intra-diskal anesthetic. Level-of-consciousness was never affected. Supplemental conscious sedation during the diskogram was generally avoided. Double needle technique using a 20 gauge guiding spinal needle followed by a long 25 gauge spinal needle accessed the center of the disk space with

routine fluoroscopic guidance. All needles were placed concordantly opposite the side of leg pain. The anticipated normal/control disk was studied first in all cases.

Disks were provoked by a moderate/rapid hand injection of 1-4.5 cc Iohexol 240 mgI/cc (GE Medical Products, Milwaukee WI, USA) under direct fluoroscopic guidance. Injection volume depended on 1) disk volume end-point, 2) post-operative disk volume end-point, 3) clearly established severe pain response or 4) exaggerated capacity in degenerative disks. Patients were kept unaware of whether a level was being provoked or which level was being studied. The initial injection response was observed by the operator and with a positive pain response, the features of the pain were clarified, VAS level of pain was established and these items recorded similar to Walsh et al.<sup>19</sup> "Concordant pain" was recorded if the provoked pain was the patient's typical/familiar pain and "non-concordant pain" was recorded if the provoked pain was not their typical pain. Fluoroscopic images were obtained for each disk level in anterior-posterior/lateral projections during and following the injections.

During disk testing, the patient's immediate injection response, response to injection end point (if present) and the patient's perception of provoked pain (concordant/non-concordant) were primarily focused on by the diskographer. Syringe/disk pressures were not recorded during injection.

If a severely painful disk space (typically VAS  $\geq$  7; concordant/non-concordant) was encountered, preservative-free lidocaine (2% strength, .5-1.5 cc, Xylocaine-MPF, Astra-Zeneca, Wilmington DE, USA) was injected into the disk in an attempt to reduce the patient's provoked pain and allow response clarity in subsequently studied disks. Volume of lidocaine was dependent upon post operative disk capacity. Lidocaine could not be injected into six painful post-fusion disks due to volume limitation.

The patient was routinely questioned regarding any pain reduction after administration of the intra-diskal lidocaine and their response was recorded either as: 1) complete/near-complete pain relief, 2) partial pain relief or 3) no significant pain relief or as a specific VAS grade reduction from the pain generated by disk provocation relative to base line pain - depending upon the patient's ability to express the change. Responses reported with the VAS were converted to the three point scale by calculat-

ing the percentage of pain reduction relative to baseline VAS pain level with: >66% pain reduction equal to complete or near-complete pain relief, 33% to 66% pain reduction equal to partial pain relief, and <33% pain reduction equal to minimal or no significant pain relief.

Post-diskogram CT (General Electric, Milwaukee WI, USA) employing both bone and soft tissue algorithms with either direct axial 3mm slice acquisition or spiral technique, 3mm axial/sagittal reformatting with isotropic voxels was obtained in all patients immediately following the diskogram.

#### *Imaging and Lidocaine Response Analysis*

Diskogram fluoroscopic images together with the post-diskogram CT of all severely painful lidocaine treated disk spaces were concordantly reviewed by two neuroradiologists experienced with lumbar diskography. Identification of epidural diskographic contrast leakage was primarily established by assessment of the fluoroscopic images with secondary inspection and correlation with the post-diskogram CT. Significant leakage at the disk margin around the needle entry site was classified as true leak but minimal contrast identified at needle entry only after needle withdrawal was not classified as leakage. Disks were judged as either *contained* (no contrast leaking from the disk space) or *leaking* (epidural contrast leakage from the disk space) itemized and tabulated. Discordant judgments were resolved by consensus.

Imaging identification of diskographic leakage in the severely painful/treated disks were compared to the response to lidocaine administration: 1) "complete/near-complete relief," 2) "partial relief" and 3) "minimal/no relief".

#### *Clinical and Provocation Lumbar Diskogram Assessment*

Responses at diskography were assessed and tabulated at both fused and adjacent levels. Concordant, non-concordant or negative response to provocation was noted. In significantly painful disks that were treated with intradiskal lidocaine, response to lidocaine administration was noted and recorded. The presence or absence of diskographic contrast leakage was assessed on diskogram fluoroscopic as well as post-diskogram CT images.

Diskogram fluoroscopic images and post-

diskogram CT was assessed for status of the fusion. Evidence of hardware breakage or loosening was assessed for and features of solid bony fusion were noted including presence or absence of contrast surrounding the inter-body fusion cage where present. Pre-procedure routine AP/Lateral, flexion/extension plain films or CT were assessed, where available, for evidence of instability and/or the presence/absence of solid fusion or hardware loosening.

#### **Results**

The results are summarized in Tables 1-5. Twenty of the 27 patients were male and seven were female with an average age of 41 years (range 26 to 54 years). Single-level fusion was present in 23 patients (L5-S1: 17 patients; L4-5: 6 patients) with two-level fusion (L4-S1) in 4 patients for a total of 31 fused levels studied by provocation diskography. The types of surgical fusion included: inter-body fusion cage only: 11; pedicle screw fixation (PSF) and inter-body fusion cage combined: seven; PSF and trans-sacral L5-S1 screw combined: two; PSF alone: three; and trans-sacral L5-S1 screw alone: four. Provocative diskogram was performed at three levels in 19 patients, four levels in seven patients and at two levels in one patient.

*Provocation diskogram responses:* In the 23 patients with a single level fusion, a positive and concordant response was noted in 15 (65%) previously fused levels (Table 1). In these 15 patients, adjacent levels were normal in 12 patients with fused level and adjacent level positive in two patients and fused level, adjacent level and an additional non-adjacent level positive in one patient. A negative response at the fused segment was noted in seven patients with an adjacent level positive and concordant in three out of seven patients and an adjacent level and additional non-adjacent level positive in one out of seven patients. In one patient, non-concordant pain was present at the fused level but an adjacent level was found to be both painful and concordant.

Four patients had two level anterior inter-body fusions that incorporated L4-5 and L5-S1 (Table 2). In two patients, a positive concordant response was noted at the L5-S1 fused level only. In patient C, a positive concordant response was encountered at L5-S1 with a non-concordant painful response at L4-5. Patient D demon-

strated a non-concordant painful response at the fused L5-S1 level, a positive concordant painful response at the L4-5 fused level and a positive concordant painful response at both the adjacent L3-4 and non-adjacent L2-3 levels.

Overall, a positive and concordant pain response was therefore noted at provocation diskography in 19 out of 31 (61%) previously fused levels (single level fusion: 15; two level fusion: four fused levels in four patients) in 19 patients. Negative response was present at nine out of 31 (29%) fused levels and a non-concordant painful response was noted at three out of 31 (10%) previously fused levels. Adjacent level concordant pain was identified in nine out of 27 (33%) patients.

#### *Diskography and post-diskogram CT Imaging features*

Diskogram and post-diskogram CT imaging features are summarized in Tables 3 and 4.

**Inter-body cage fusions:** In 11 of 19 painful concordant fused levels, anteriorly placed inter-body fusion cages were present (cages only: six levels; cage and pedicle screw fixation: five levels). Contrast surrounded the cage upon diskography injection in five of these 11 concordant levels (Table 3; Figure 1).

At three cage-fused levels (cage only: two; cage and pedicle screw fixation: one) non-concordant pain was provoked at diskography and at eight cage-fused levels (cage only: seven; cage and pedicle screw fixation: 1) provocation diskography was negative. Contrast was noted surrounding the cage in two out of three non-concordant painful levels but only one out of eight negative levels (Table 4).

No evidence of pedicle screw fixation hardware loosening or breakage was present.

**Pedicle screw fusion only:** At two out of 19 painful concordant fused levels, pedicle screw fixation only was present. At both levels, the fusions appeared intact but diskographic contrast leakage was noted from the injected disk space (Table 3; Figure 2).

In the third patient, provocation diskography was negative (Table 4).

**Trans-sacral screw fusions:** Evidence of trans-sacral screw loosening was noted in three out of the four trans-sacral screw-only patients (increased fibrous tissue surrounding screw and fibrous tissue contrast tracking at diskography: two; bone remodeling increased fibrous tissue surrounding the screw and contrast tracking at diskography: 1). Fibrous tissue surrounding the trans-screw was noted in one out of two patients with trans-sacral screw combined with pedicle screw fixation (Table 3; Figure 3).

#### *Lidocaine response*

Intra-diskal lidocaine was injected at 13 of 19 painful concordant levels but was not injected at six levels due to volume limitations of the post-fused disk space (Table 3).

**Inter-body cage fusions:** Lidocaine could be injected at six out of 11 levels with inter-body cage fusion with five not injected due to volume limitation in the post-operative disk space. Five out of six lidocaine injected levels were contained (total pain relief: two, partial pain relief: two, no pain relief: one) with a single lidocaine injected level demonstrating diskographic contrast leakage and partial improvement.

**Pedicle screw fusion only:** One out of two painful concordant disks post pedicle screw

Table 1 Single level fusion - observed pain response: 23 Patients; both fused and adjacent levels

Fusion Level		Adjacent Levels		Surgical Revision
Response	# Pts	Pos	Neg	
Positive/Concordant*	15 (65%)	3 (20%)	12 (80%)	9
Negative**	7 (30%)	4 (57%)	3 (43%)	2
Non-concordant	1 (5%)	1	0	0
Total	23	8 (35%)	15 (65%)	11

Legend: #Pts: number of patients; Pos: positive and concordant at provocation diskography; Neg: negative at provocation diskography; \*: inter-body fusion cage only: 2, pedicle screw and inter-body fusion cage: 5, pedicle screw fixation only: 2, trans-sacral screw only: 4, trans-sacral screw and pedicle screw: 2; \*\*: inter-body fusion cage only: 6, pedicle screw and inter-body fusion cage: 1, pedicle screw fixation only: 1.

fixation could be injected with lidocaine and demonstrated total pain improvement and diskographic contrast leakage.

*Trans-screw fusions:* All four painful concordant disks with trans-sacral screw-only fixation were contained with intra-diskal lidocaine

Table 2 Two-level anterior inter-body fusion - observed pain response: 4 patients; both fused and adjacent levels

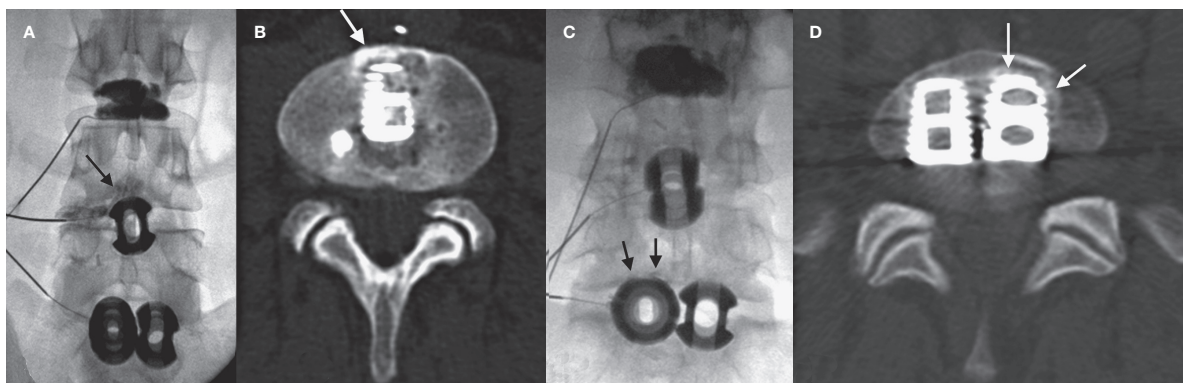
Patient	Fused Levels		Adjacent Level	Surgical Revision
	L5 – S1	L4 – L5	L3 – L4	
A	+/Con	Neg	Neg	–
B	+/Con	Neg	Neg	Y
C	+/Con	NCP	Neg	–
D	NCP	+/Con	+/Con	Y

Legend: +/-con: positive and concordant at provocation discography; neg: negative at provocation discography; NCP: non-concordant pain provoked at provocation discography.

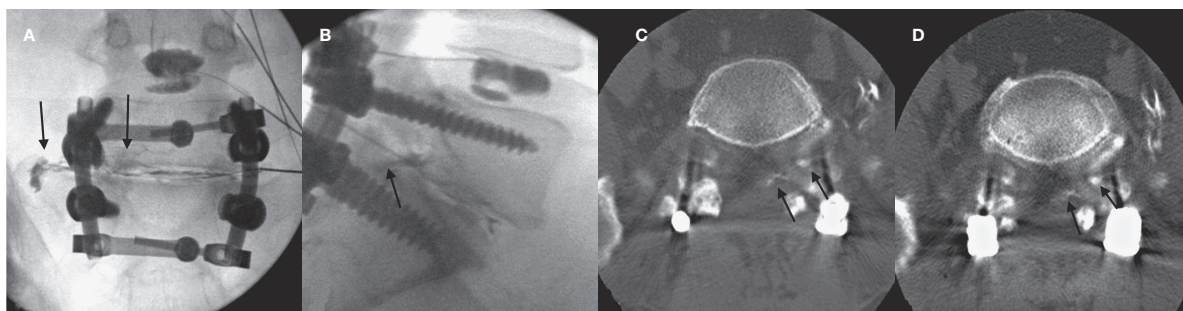
Table 3 Diskogram and post-diskogram CT imaging features in 19 painful/concordant fused levels

Fusion Type	# Pts	Disk Leak	Disk Cont	Lidocaine Response	Space/Contrast Surrounding Cage	Pedicle Screw Loosening	Likely/Definite Trans-screw Failure/Loosening
Cage Only	1		Y	P	N	–	–
	1		Y	T	N	–	–
	1		Y	*	N	–	–
	1	Y		*	N	–	–
	1		Y	*	Y	–	–
	1		Y	*	Y	–	–
Subtotal	6	1	5	2/2	2/6	–	–
Pedicle Screw & Cage	1	Y		P	N	N	–
	1	Y		*	N	N	–
	1		Y	P	Y	N	–
	1		Y	T	Y	N	–
	1		Y	n/c	Y	N	–
Subtotal	5	2	3	3/4	3/5	0/5	–
Pedicle screw Fixation Only	1	Y		T	–	N	–
	1	Y		*	–	N	–
Subtotal	2	2		1/1		0/2	
Pedicle Screw & Trans-screw	1	Y		P	–	N	Y
	1	Y		P	–	N	N
Trans-screw Only	1		Y	P	–	–	Y
	1		Y	T	–	–	Y
	1		Y	T	–	–	Y
	1		Y	P	–	-	N
Subtotal	6	2	4	6/6	0	0/2	4/6
Overall Total	19	7	12	12/13	5/11	0/9	4/6

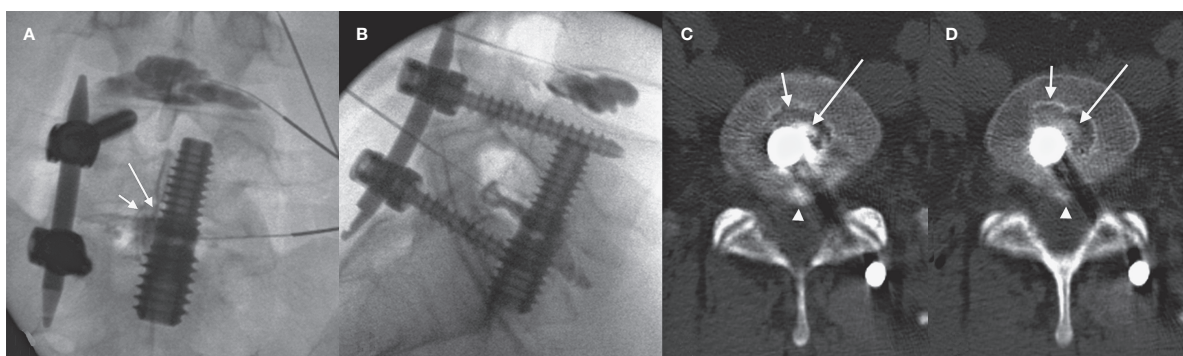
Legend: Y: yes; N: no; T: complete relief of provoked pain after intradiskal lidocaine injection; P: partial relief of provoked pain after intradiskal lidocaine injection; Cont: contained; \*: disk not injected with lidocaine due to volume limitation..



**Figure 1** Patient is a 42-year-old man with a longstanding history of chronic low back pain with multiple prior lumbar surgeries including inter-body cage fusion at the L4-5 and L5-S1 levels. Post-fusion, he continued to have persistent low back pain. A) AP diskogram image demonstrates contrast injected into the L4-5 disk space. Contrast is seen in the residual postoperative disk space as well as surrounding the upper margin of the cage (arrow). The patient had non-concordant pain at L4-5 with no response to lidocaine injection. B) Post diskogram CT at L4-5 demonstrates contrast projecting into the peri-cage fibrous tissue (arrow). C) AP diskogram image demonstrates contrast injected into the L5-S1 disk space. A small amount of diskographic contrast is pooled around the inter-body fusion cage (arrows), but no diskographic contrast leakage was demonstrated. The patient had positive concordant pain at this level with partial improvement after lidocaine injection. D) Post diskogram CT at L5-S1 demonstrates contrast surrounding the left cage (arrows).



**Figure 2** Patient is a 32-year-old man with a longstanding history of low back pain thought to be related to L5-S1 spondylolysis and spondylolisthesis. Approximately 1 year earlier the patient had undergone bilateral pedicle screw fixation at L5-S1. No improvement was seen in his symptoms. At diskography, the patient had 10/10 positive concordant pain at L5-S1 which was completely eliminated with lidocaine injection. A,B) AP and lateral diskogram images demonstrate residual degenerative disk changes in the L5-S1 disk with leakage of contrast into the epidural space and foramen laterally on the left (arrows). C,D) Post diskogram CT again demonstrates the active leak of diskographic contrast material into the epidural space and neural foramen on the left (arrows).



**Figure 3** Patient is a 33-year-old man with a longstanding history of chronic low back pain after a lifting injury. Three months earlier the patient had had left-sided pedicle fixation and trans-sacral screw placement at L5-S1. Post-fusion, he continued to have 9/10 low back pain. At diskography, the patient had 9-10/10 positive concordant pain at L5-S1 with partial improvement of provoked pain with lidocaine injection. A,B) Frontal and lateral diskogram images demonstrate contrast seen pooling around the trans-sacral screw (large arrow) with active leakage (small arrow). C,D) Post diskogram CT demonstrates contrast surrounding the trans-sacral screw (large arrow) and peri-trans-sacral screw fibrous tissue (small arrow) with contrast leakage into the anterior epidural space (arrowhead). Subsequently, he was surgically revised with significant improvement.

Table 4 Diskogram and post-diskogram CT imaging features: 9 negative fused levels and 3 non-concordant painful fused levels

Fusion Type	Negative at Diskography				Non-Concordant Pain		
	# Pts	# Disk Leak	Space/Contrast Surrounding Cage	Pedicle Screw Loosening	# Pts	Space/Contrast Surrounding Cage	Pedicle Screw Loosening
Cage Only	7	0	0	–	2	1	–
Pedicle Screw & Cage	1	0	1	0	1	1	0
Pedicle Screw & Trans-screw	–	–	–	–	–	–	–
Pedicle Fixation Only	1	0	–	0	–	–	–
Trans-screw Only	–	–	–	–	–	–	–
Total	9	0	1/8	0/2	3	2/3	0/1

Legend: #Pts: number of patients; # Disk Leak: number of disks with diskographic contrast leakage.

Table 5 Results of redo-fusion: 13 patients with painful fused and/or adjacent levels

Post Redo Fusion Pain	Fusion + Adjacent +	Fusion + Adjacent -	Fusion - Adjacent +	Total
Significant Improvement	4	3	2	9
Moderate Improvement	-	1	-	1
No Improvement	1	2	-	3
Total	5	6	2	13

Legend: Fusion + : fused level positive at provocation diskography; Fusion - : fused level negative at provocation diskography; Adjacent + : adjacent level positive at provocation diskography; Adjacent - : adjacent level negative at provocation diskography.

resulting in partial (two levels) or complete (two levels) pain improvement. In the two concordant disks with trans-sacral and pedicle screw fixation, both demonstrated diskographic contrast leakage and both resulted in partial provoked pain improvement after lidocaine administration.

#### Pre-procedure evaluation

Pre-procedure plain films or CT were available in 14 patients. Routine AP/Lateral images were negative in seven patients with positive bony fusion noted in one and evidence of fibrous loosening surrounding a trans-sacral screw in one. Pre-procedure CT was negative in two patients and demonstrated evidence of bony fusion at the fused level in one patient. Flexion-extension plain films were negative in two patients. Post-diskogram CT demonstrated confirmed fusion in the two patients identified

on pre-procedure imaging both negative at diskography and in one additional patient negative at diskography (cage). Two patients with single level fusion positive at diskography demonstrated evidence of bony fusion on post-diskogram CT (cage and PSF: one; PSF only: one). In two patients with double-level cage fusion, evidence of bony fusion was present at a single level in one patient and at both levels in one patient. Post-diskogram CT evidence of bony fusion was identified as inter-endplate bridging bone, para-facet bridging grafted bone or direct facet fusion.

#### Fusion revision

The fusion was revised in 13 patients with positive diskography as summarized in Table 5. In 11 patients the painful fused level was revised and where adjacent levels were positive or demonstrated non-concordant pain, the ad-

adjacent level was included in the new fusion construct. Overall seven out of 11 (64%) had significant improvement in their pain with moderate improvement in one out of 11 (9%). In three out of 11 (27%) patients no improvement occurred after redo-fusion and either spinal cord stimulator or intra-thecal pain pump was placed. In two patients, concordant diskogenic pain was identified adjacent to the diskogram-negative original fusion. In both patients, the adjacent level was incorporated into the original fusion and significant pain improvement resulted.

## Discussion

Persistent or recurrent LBP can occur following spinal fusion. Naturally progressive degenerative disease likely occurs in this population and abnormal but clinically quiescent levels may deteriorate further, becoming independently symptomatic. Altered spine motion can lead to greater stresses at adjacent non-fused levels leading to facet or sacroiliac joint pain<sup>1,2</sup>. Altered motion also affects the adjacent disks with more rapid degeneration above or below fused levels well recognized.<sup>1-4</sup>. Problems at the fused level may also develop including pseudoarthrosis with gross loosening of hardware leading to inadequate fusion, hardware breakage or adjacent bone fracture<sup>8-10,12-15,20-23</sup>.

Diskogenic low back pain at previously fused levels has been demonstrated in two reports after technically successful lumbar fusion<sup>16,17</sup>. Other potential causes of residual diskogenic pain after lumbar fusion have been suggested including 1) incomplete solid fusion with subtle yet painful residual motion and 2) leakage of irritating degenerative disk byproducts through a residual annular defect<sup>24</sup>. Our experience reconfirms many of these observations and suggests that persistent or recurrent diskogenic pain at a previously fused or adjacent disk level is an important but complex problem after technically successful fusion.

In our patients, convincing evidence of hardware loosening that developed after technically successful surgical fusion was noted in only four patients. Three patients with L5-S1 trans-sacral screw fusion demonstrated the development of inadequate bony purchase with evidence of fibrous union.

One additional patient with L5-S1 trans-sac-

ral screw developed fibrous union pressure-related bone remodeling and screw migration. In patients with pedicle screw fixation alone or pedicle screw fixation in addition to inter-body fusion, no specific evidence of hardware loosening, hardware breakage or hardware fracture was found in any case.

The determinants for clinically 'successful' lumbar fusion are controversial<sup>25</sup>. Histologically, fusion is deemed present when bridging trabecular bone is identified. Radiographic criteria based on flexion-extension image comparison vary from one to five degrees of motion contingent upon measurement error and minor potential hardware flexibility<sup>5,25</sup>. By CT imaging, demonstration of bridging bone is helpful, but autograft bone chips are typically inserted into the cages at placement and assessment is often difficult to interpret in 360 degree fusions where posterior metallic hardware is also present. Some surgeons feel that fusion solidity can only be reliably assessed at direct open inspection<sup>25</sup>. Even minor motion might result in significant residual or recurrent pain, and this degree of mobility might be beyond standard assessment<sup>24</sup>.

In our patients, recurrent or persistent diskogenic pain at provocation was encountered in a variety of fusion constructs. With inter-body fusion (anterior or posterior-lateral), free and attached annular fragments as well as intermixed degenerative nucleus are removed through a surgically created annular access window. The majority of the peripheral annulus and residual attached inner annulus are left behind for peripheral structural support with metallic or ceramic cages and bone graft material placed in the disk cavity created to establish fusion. With isolated pedicle screw fixation, in addition to the posterior fusion, discectomy is often performed with similar removal of free and attached annular fragments as well as intermixed degenerative nucleus. In trans-sacral screw fixation, the screw is placed after sacral/vertebral body tapping and central disk fragment and nucleus removal using a brush extractor.

In all fusion constructs, portions of peripheral and intermediate portions of the annulus or endplates remain. Deeply penetrating endplate or annular-originating nociceptors may still be present even after disk space debris removal. The more peripheral areas of annular derangement may remain even after disk space preparation.

Nociceptor innervated focal radial tear with adjacent annular injury (i.e. lamellar tears) may

be present in addition to peripheral concentric annular tears adjacent to the innervated peripheral annular margin. After fusion, granulation tissue develops in the operated-upon disk space with likely neurovascular nutritional support from the peripheral annulus or adjacent end plates. A complex combination of residual diseased annulus and granulation tissue are therefore potentially present that could represent a source of residual or recurrent disk pain after fusion.

In patients with inter-body fusion with disk space implanted cages, contrast injected at diskography surrounded the implanted cage in five out of 11 patients (45%) with concordant painful disks (Table 3). Contrast surrounding the cage(s) was present in both anterior cage fusions as well as 360 degree fusions combined with pedicle screw fixation but was also seen in the two patients with non-concordant pain and in one patient with a non-painful level (Tables 3 and 4). The implication of this observation is not clear.

Distension of space surrounding a cage could merely transmit pressure to the endplates or annulus, challenging other potentially painful areas of the residual disk. Injection of contrast into the fibrous postoperative disk space might not reach the cage. Alternatively, this observation might suggest failed cage incorporation with the potential for failed fusion and the presence of residual motion.

Two out of three patients with pedicle screw fixation only had concordant pain at diskography (Table 3).

Diskographic contrast leakage was present in both instances and lidocaine could be injected into one with complete elimination of provoked pain.

The reason for residual or recurrent pain in these disks is not clear. Ongoing and persistent degeneration of the remaining disk contents could still be present with reoccurring residual annular distention or persistent leakage of irritating disk contents.

Two out of six patients with trans-sacral screw fusions had accompanying pedicle screw fixation. In both fusions, diskographic contrast leakage was present with partial pain relief after intra-diskal lidocaine (Table 3). As with standard pedicle screw fixation, ongoing degeneration of the remaining disk contents could still be present with reoccurring residual annular distention or persistent leakage of irritating disk contents. The four remaining patients with

trans-sacral fusion only had contained disks and demonstrated partial or total pain relief with intra-diskal lidocaine. As stated above, three of the four demonstrated evidence of hardware loosening likely contributing to their pain with intra-diskal lidocaine rendered total pain relief in two of these patients with partial relief in one.

Response to intra-diskal marcaine injection has recently been reported in a postoperative patient demonstrating solid posterior vertebral body fusion but absent anterior vertebral fusion with residual diskogenic pain documented at provocation diskography<sup>17</sup>. In our patients, a positive response to intra-diskal lidocaine injection was noted in 12 out of 13 painful concordant disks tested. Both complete (four contained; one leaking) and partial (four contained, three leaking) relief of provoked pain was noted (Table 3). As stated above, the response to intra-diskal local anesthetic could carry implications regarding the source of pain at the studied level.

When disks respond to lidocaine but are contained, anesthetic presumably reaches the aggravated pain fibers either completely with total pain reduction or partially with incomplete pain reduction. In these instances, pain could be related to in-growth of deep nociceptive fibers or residual pain of the peripheral annulus.

When a level responds but demonstrates diskographic contrast leakage, local anesthetic might be acting upon pain provoked from epidural expression of irritating degenerative disk by-products<sup>24</sup>. A positive response to intra-diskal anesthetic also helps confirm the positive provocation diskogram pain response at the studied level.

Adjacent level concordant pain was also noted in a significant number of our patients. In three out of 15 patients with single-level fusion and one patient with two-level fusion, an adjacent level was positive and concordant in addition to a previously fused level. In five out of eight patients with negative or non-concordant single-level fusion, an adjacent level was positive and concordant with the patients LBP (Table 1).

Diskography can be helpful and important therefore in identifying both 'clinically significant' adjacent-level disease as well as confirming 'clinically successful' lumbar fusion.

Several limitations exist due to the retrospective nature of this study. Provoked pain re-

sponse at fused levels in patients without post-fusion recurrent/residual pain is not known and therefore a true control population is lacking. It is also not known whether recurrent pain at a previously operated on level is necessarily the same as the original pain. It might be appropriate to study all levels for pain recurrence even if the patient's original pain resolves and newly developed pain is different. Fusion is commonly performed without pre-procedure diskography and therefore the preoperative response of the majority of these fused disk levels is not known. Further studies will be necessary to understand this pain response more fully.

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## Conclusion

Provocation lumbar diskography at previously fused disk levels can elicit concordant pain response in a number of patients with persistent/recurrent pain symptoms. Pain can be present, either alone or in combination, at both previously fused levels as well as levels adjacent to fusion. Response to intra-diskal lidocaine occurs, as in routine diskography, with potential implication for the source of disk pain as well as reinforcing the positive provocation diskogram response. Further studies are necessary to better understand this postoperative response.

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